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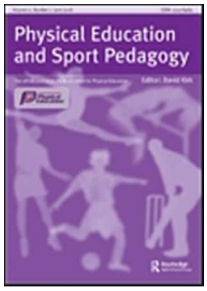

The influence of content knowledge on teaching and learning in traditional and Sport Education contexts: An exploratory study

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Running Head: Teacher Behaviour and Student Learning in Swimming

The influence of content knowledge on teaching and learning in traditional and Sport Education contexts: An exploratory study

Abstract

Background. Our understanding of the role in which CK can strengthen instructional models and how that knowledge matters for professional development is limited. It is contended that mere use of an instructional model is insufficient to impact psychomotor learning in meaningful ways.

Purpose. This study was conducted to investigate how a teacher's enacted Pedagogical Content Knowledge (PCK) differed as a function of Content Knowledge (CK) and Sport Education (SE); and to investigate the relative contribution of CK and Sport Education on student learning in terms of swimming performance.

Methods. Four intact classes comprising 88 secondary school students (age: 16-17 years) were randomly assigned to a Traditional, a Sport Education, a Traditional-CK, and a SE-CK group. All classes were taught by the same teacher during a 10-day unit of instruction in the front crawl.

Results. Results showed that the teacher's PCK differed as a function of improved CK. For verbal representations, the amount of cues in the Traditional-CK and SE-CK groups increased about six-fold compared to the Traditional and Sport Education group. For visual representations, more partially incorrect demonstrations were observed than correct demonstrations in the Traditional and the Sport Education group. More mature and developmentally appropriate tasks were observed in the

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Traditional-CK and SE-CK group compared to the Traditional and the Sport Education group. Students in the Traditional-CK and SE-CK groups demonstrated a significant reduction of their amount of strokes on 50m compared to the Traditional group. A significant interaction effect revealed a larger increase in swimming performance in the CK groups compared to the Traditional and Sport Education group. Finally, students in the Sport Education group swam significantly more laps than their counterparts in the other groups.

Discussion and conclusion. These results show the impact on student learning when CK was added to both traditional and Sport Education conditions and contribute to the literature for pre- and inservice teachers. The Sport Education model did not contribute to students' swimming performance. Students in the Traditional and Sport Education group did not get the same quality of instruction as students in the Traditional-CK and SE-CK condition. The latter groups received content that was presented differently both as a presentation and in terms of the actual task. In short, students in the Traditional and Sport Education conditions experienced the content differently than those in the Traditional-CK and SE-CK condition. These instructional differences resulted in students in the Traditional-CK and SE-CK condition improving their swimming performances in terms of technical efficiency and in terms of 50m times.

Key Words

Specialized Content Knowledge; Professional Development; Pedagogical Content Knowledge, Swimming

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Introduction

Policy discourse relative to teacher quality can refer to many things including teacher preparation programs (e.g., coursework-content studied, graduate level training), life experiences (e.g., socio-economic status, teaching experience,), test scores (pre-service teacher assessment) and ongoing professional development (Darling-Hammond 2001; Harris and Sass 2011). Regardless of the agenda for teacher quality, all discourses share a common belief that teacher quality has an impact on student learning through the creation of quality learning environments (Darling-Hammond 2001). That is teachers use their knowledge and experience to arrange conditions that facilitate student learning. In this view, learning environments encompass teacher behavior (e.g., clarity of task presentation, class management) as well as teaching models (e.g., peer tutoring, direct instruction, Sport Education).

The contemporary policy emphasis on teacher quality and learning environments represents a macro view of teaching that considers both the daily as well as the cumulative effects on student learning. The focus is not only on proximal measures of teaching effectiveness such as successful trials (Silverman 1985; 1990) or Academic Learning Time (Siedentop, Tousignant, and Parker 1982), but also includes distal and outcome indicators of student learning (e.g., summative measures such as game performance and skill assessments).

One of the important contributions to understanding the role of learning environments in physical education has been Metzler's (2011) rationale for his

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conception of teaching models. Metzler (2011) has argued that instructional models and content should be matched to maximize the intended learning outcomes (Metzler 2011). For example, if one were teaching swimming to beginners, the safety of the students may necessitate direct instruction instead of more student centred methods. In contrast, teaching swimming to experienced swimmers allows for a greater range of instructional models (e.g., Sport Education or peer tutoring). The rationale is grounded in the assumption that different learning environments created by instructional models produce different learning outcomes.

From a research design perspective, teaching models can be viewed as pedagogical interventions consisting of instructional and in some cases managerial elements, and it is the elements of the packages that create the different learning environments. For example, peer tutoring uses elements of accountability in the form of group contingencies to develop and maintain the reciprocal roles of tutor and tutee (Iserbyt et al. 2011). Peer tutoring is a relatively simple learning environment compared to Sport Education (Siedentop, Hastie, and van der Mars 2011). Sport Education consists of a number of elements such as organizing the unit into seasons. These include affiliation through the use of persisting groups where students are placed in teams for the duration of the season, record keeping to both motivate and hold students accountable, competition to allow students to apply their knowledge, skills and values (e.g., fair play); and culminating experiences that serve to bring festivity and recognition of student accomplishment (Siedentop et al.

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2011). Collectively, these elements form a sophisticated instructional and managerial infrastructure that comprises the learning environment.

Concurrent with concerns for teacher quality has been a focus on the role of content knowledge (CK) in learning environments (Ball, Thames, and Phelps 2008). The argument is grounded in the assumption that CK impacts pedagogical content knowledge or PCK (Kleickmann et al. 2013; Shulman 1986, 1987). When Shulman (1987) proposed focusing attention on CK in teaching, his focus was not merely on CK and PCK as knowledge bases that impact teaching and student learning, but he also situated them between five other knowledge bases: curricular knowledge, general pedagogical knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends and purposes. At the time, he conceptualized these as related and parallel influences that impacted student learning. However, shortly after proposing this model he modified the relationship in a way that all researchers have since used, which is that the knowledge bases act on and through PCK (Gudmundsdottir & Shulman, 1987). More than two decades following Shulman's (1986) initial conceptualization of PCK, a teacher's content knowledge is considered the most influential of the knowledge bases that impacts PCK and in turn student learning (Abell 2008; Ball et al. 2008; Krauss et al 2008; Ward 2009).

The distinction between CK and PCK has not been well understood nor elaborated until Ball et al. (2008) classified CK into two domains in mathematics. The first domain was titled common content knowledge (CCK),

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which was knowledge needed to perform a mathematical task, such as answering a math problem. The second domain was labeled specialized content knowledge (SCK). It refers to knowledge and skills that represent mathematical reasoning and error analysis. Furthermore, Ball et al. (2008) describe CCK as knowledge that is used by individuals who have been educated in the task (e.g., multiplication), whereas, SCK is "special knowledge" that is uniquely needed by teachers to teach CK (e.g., teaching progressions for two digit multiplication). Thus, teachers must know how to perform the steps for the procedure to provide the correct answer when solving a multiplication problem such as 27 x 56 (i.e., CCK). But they must also know what errors students are likely to make and how to correct them (i.e., SCK). SCK can be differentiated from PCK in the following way. Consider the problem of a teacher teaching a fitness unit and using the basic sit-up (knees bent, hands on shoulders) as the task presented to the students. For some students this basic sit-up will be too hard and for others too easy. In order to adapt the task to the differing needs of the students (i.e., PCK) the teacher must first know task progressions that are easier (e.g., placing hands on the ground beside the hips and placing the chin on the chest) and more difficult (e.g., crunches). This sequence of task progressions is SCK and it is hypothesized by Ward (2009) that knowing this sequence specifically strengthens the teacher's PCK.

In the context of this discussion, the role of content knowledge relative to outcomes of a teaching model is important. Metzler's (2011) argument for the

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use of CK in teaching models is primarily based in the alignment between the purpose-outcomes of the model and the content best suited to support the outcomes. In this study, our focus is on psychomotor outcomes. Most teaching models are content free with the exception of adventure-based learning (Sutherland, Ressler & Stuhr, 2011). The influence of CK on PCK is by its nature subject, grade level and context specific (Rovegno, 2006). Findings from math and science repeatedly show that "appropriately selected and implemented mathematical tasks lay the foundation for students' construction of knowledge and represent powerful learning opportunities" (Krauss et al, p. 717). Similarly, Ward (2013) has argued that CK can be best seen in quality task selection and its representation to students, noting that, "If you use low-quality tasks students acquire something different than if you used high-quality tasks" (Ward, p. 437). Inter- and intra-task adaptions such as refining and extending tasks have been shown to be substantively different as a function of a teacher's CK (Ayvazo & Ward, 2011; Schemmp, Manross, Tan et al, 1998). Importantly, intra-task adaptation differentiates between the effectiveness of the same teachers in different units. Because it is here that CK is adapted to specific needs of the students.

Studies of sport educatio have repeatedly emphasized the importance of CK in having an impact upon psychomotor outcomes. Using discrete skills tests Hastie (1998) and Hastie and Trost (2002) reported pre-post difference in skill development and knowledge by students who were taught using Sport Education. A well designed study by Pritchard, Hawkins, Wiegand and

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Metzler (2008) reported gains, but no significant differences between volleyball taught using Sport Education versus a more traditional format focusing on game performance. In contrast, Browne, Carlson and Hastie (2004) reported significant differences in skill levels for rugby. Interpreting these findings can be problematic because the confounding issue in these studies is the assumption that the content (e.g., progressions and tasks) was taught correctly, was appropriate, and that students received quality feedback. If knowing the content for teaching is important, then knowing the content for teaching Sport Education requires knowing how to rearrange the content in such a way that it can be taught in small groups *by students.* Ko, Wallhead & Ward (2006) suggest that one reason Sport Education is not used as often as it might be lies not with the teachers' understanding of the model but "because their content (sport subject matter) knowledge was limited in ways that did not allow them to use the Sport Education curriculum in the manner it was designed" (p. 412).

Our understanding of the role in which CK can strengthen instructional models and how that knowledge matters for professional development is limited. In this study, we systematically examined teaching and learning in four instructional conditions for learning the front crawl in swimming. We determined the relative contributions of traditional instruction, a Sport Education unit, traditional instruction strengthened with knowledge of SCK, and Sport Education strengthened with knowledge of SCK. Each was a 10-day swimming unit. Our research questions were: (1) How does the teacher's

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enacted PCK differ as a function of CK and Sport Education; (2) What is the relative contribution of CK and Sport Education to student learning in terms of swimming performance?

Conceptually, we position this study at the nexus of teaching effectiveness studies and PCK studies. Like these approaches, we are interested in examining the relationships between teaching and student learning. Specifically our interests are in determining the role of CK upon enacted PCK, and in turn the effect that PCK has on student learning. We also align ourselves with inquiry that is occurring on this topic in math (Ball et al. 2008; Kleickmann et al. 2013; Krauss et al. 2008;) and in science (Abell 2008). Methodologically, we situate ourselves within the more than four decades of behaviour-analytic literature in physical education and sport where direct observation and measurement of student performance are considered measures of student learning (Martin 2003; McKenzie 2010; Rushall and Siedentop 1972; Ward 2006).

Methodology

Participants and setting

The teacher in this study was male and 39 years of age. He had been certified to teach K-12 PE for 17 years and had been teaching PE (including swimming) in the school where the experiment was conducted for 16 years in grades 9 through 12. He had not swum competitively and had not been involved in coaching swimming. The teacher was selected based on three criteria: (1) agreeing to participate in this study, (2) being able to teach a 10-

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day swimming unit, and (3) not being familiar with the Sport Education model. The teacher was asked to self-report his swimming knowledge in the four CK domains described by Ward (2009) using the categories good, sufficient, or insufficient. Except for knowledge of task progressions (sufficient), he reported all knowledge domains as 'good'.

Four intact 10th grade classes (n = 88) from a secondary school in Flanders, Belgium were selected to participate in this study. Students averaged 16 years of age and received two 50-minute lessons of PE per week. Students had received swimming classes in the previous years, which were primarily focussed on breaststroke. The school's PE curriculum was arranged so that one of the two lessons each week was a swimming lesson with the other lesson occurring in the school's gymnasium where court sports were taught. Instructional time in all swimming classes averaged 41 minutes (range 39-43 minutes). This school was selected because of its proximity to the university, its collaboration with the university's Physical Education Teacher Education program, and because it has a swimming pool on its campus. The swimming pool had four lanes and the pool's dimensions were 16.67 by 8 meters. Students had to swim three laps to cover a 50m distance. Average class size for PE in this school was 18 to 25 students. Informed consent for the study was received from the teacher, the students' parents and the principal of the school after approval from the first author's Institutional Review Board was obtained.

Study Design

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We set up an experimental design to systematically investigate teacher behaviour and student learning as a function of four conditions. Classes were randomly assigned to one of four instructional conditions. First, the teacher taught classes using a Traditional and a Sport Education (SE) approach. In the Traditional class, the teacher was asked to teach his typical 10-day unit of front crawl swimming. In the Sport Education class, the teacher taught his 10-day unit of crawl swimming using the Sport Education model. The content in this class was similar to the Traditional class. Since the teacher was not familiar with Sport Education, he received a workshop designed to teach him Sport Education prior to the start of the study. Once these units were completed, the teacher participated in a CK workshop after which he again taught two classes. In the Traditional-CK class, the teacher taught ten lessons using the CCK and SCK instructed in the workshop to inform his PCK. He did not use Sport Education in this class. In a forth class, SE-CK, the teacher combined Sport Education with CCK and SCK.

Independent Variables

Two independent variables were used, Sport Education and CK. Both were delivered as a 1on1 teacher workshop. In addition, teacher feedback related to the implementation of Sport Education and CK in the Traditional-CK and SE-CK lessons was provided.

Sport Education workshop. The teacher in this study attended a three hour Sport Education workshop led by the principal investigator who was familiar with the Sport Education curriculum and the challenges implementing

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this model in schools. This short duration workshop was possible due to the one-to-one tutoring setting. Prior to starting the workshop, the teacher was asked to read the 'Complete guide to Sport Education' handbook (Siedentop et al., 2011). During the workshop the teacher was taught the 10 Sport Education features described by Siedentop et al. (2011). Table 1 lists these features. The Sport Education features were introduced together with specific examples for a swimming unit. In addition to the workshop, the lead author and the teacher planned the Sport Education infrastructure to be implemented in the swimming unit. Finally, the teacher trialled the Sport Education unit with a swimming class not involved in this study prior to implementing Sport Education in the study. During this trial the teacher received feedback from the lead author and made refinements to the Sport Education unit.

Swimming content knowledge workshop. After teaching the 10-day unit of front crawl swimming to the Traditional and the Sport Education class, the teacher received a CK workshop. The content of the workshop was organized around the CK packet. A CK packet is a body of knowledge, in this case swimming, that contains both CCK and SCK that is appropriate for a particular grade context such as upper elementary or middle school. It is not PCK, because no shaping of the content to meet specific student needs had yet occurred (Author Citation, in press). The knowledge packet was developed by the third author of this study who is a swimming expert and was validated through discussion and approval by eight other swimming experts: one professor and two teaching assistants in swimming at university level, one

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researcher specialized in secondary school teaching programs, and four swimming coaches at the national level. All experts agreed on the content and task progressions in the packet and on its developmental appropriateness for teaching a crawl unit in a secondary school setting as described above. The goal of the CK packet was to improve the efficiency of the crawl stroke using SCK. The focus was on two topics, namely: (1) reducing drag by improving the streamlined position of the swimmers to swim faster; and (2) a reduction of the number of arm strokes per distance. Since swimming speed equals stroke length multiplied by stroke rate, it is generally accepted that a reduction in stroke rate for the same speed represents an increase in effectiveness of the swimming technique because the swimmer covers more distance per stroke (Costill 1985). The teacher was asked to read the CK packet before starting the workshop. The workshop duration was three hours and was conducted over three days. The first author led the workshop which consisted of three main topics: (a) introduction of the CK packet, (b) modelling the CK packet and learning how to teach its content, and (3) evaluating whether the teacher mastered the content during the workshop and upon completion. The latter was done by asking the teacher to demonstrate CCK and SCK to the research assistants every time a new (technical) skill and progression was introduced. The first author evaluated the teacher's performance by means of observation. When the teacher reached a 100% correct task presentation of all skills in the packet, the workshop was completed.

Dependent variables

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Teacher variables. Teacher behaviour (i.e., PCK) in all classes over the 10-day unit was coded into three categories: verbal representations, visual representations, and maturity/appropriateness of the task. For more detail on these variables see Ayvazo and Ward (2011), and Kim (2011). Verbal representations consisted of instructions, descriptions, analogies/metaphors, cues, and congruent feedback. Visual representations consisted of correct demonstrations, partially correct demonstrations, incorrect demonstrations, the use of task cards, and physical aids. Task maturity and appropriateness was coded on a scale ranging from 1 (i.e., immature and inappropriate) to 4 (mature and appropriate).

Arm strokes over 50m. Students' amount of strokes over 50m was measured in lesson 1 and lesson 10 of all classes in a standardized manner. Students started in the water, keeping one hand on the pool's edge. Each student swam in a lane to avoid disturbance from other swimmers. Every student was observed by a trained assistant to count the number of strokes students performed over 50 m. A finger entering the water was counted as one stroke.

50 m sprint. Swimming performance was measured by means of 50m sprint time in lesson 1 and 10 in a standardized way. After a whistle blow from the teacher, students dove into the water and swam 50m as fast as possible. One student was swimming per lane and was observed by one trained assistant who measured time using a chronometer. Time started at the whistle blow and stopped when the student touched the wall. Swim time in seconds was

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converted into a score taking into account the exponential increase of drag and thus energy cost with increasing speed. The Belgian swimming record was set as a benchmark and equals a score of 1000. Individual performances were then calculated using the following formula: (Belgian record/swim time)^3 x 1000 = individual performance score. This conversion has previously been used to compare performances of swimmers of different levels of expertise and genders (Daly and Vanlandewijck 1999). Improving a personal best time with 1 second is more difficult for a fast swimmer than for someone slower. Hence a 1 second improvement at a higher speed represents more points than at a low speed.

Swimming volume (laps). In all lessons from all classes, the amount of laps swum per student was recorded in real time by research assistants as a measurement of work completed.

Sport Education implementation fidelity

Hastie and Casey (2014) have argued that curricular interventions should provide (a) "a rich description of the curricular elements of the unit, (b) a detailed validation of model implementation, and (c) a detailed description of the program context." The program context has previously been described in the participants and setting section. In addition, neither the teacher nor the students had previous experience in models-based instruction. Table 1 provides a description of the Sport Education training and implementation fidelity on two levels. The first part of Table 1 describes the teacher training to teach Sport Education. The second part of the table describes the preparation

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and implementation phase of the Sport Education model based on the 10 features identified by Siedentop et al. (2011). Table 1 also provides validation of model implementation indicating the presence and absence of the elements throughout the unit and whether these features occurred in both the Sport Education and SE-CK group.

INSERT TABLE 1

Data collection

Swimming lessons in all classes were videotaped with two cameras, capturing all students in the swimming pool. A third camera manipulated by a research assistant was used to constantly capture the teacher. The teacher also wore a wireless microphone to capture his voice. Recordings from the camera following the teacher and the microphone were afterwards synchronized to facilitate the analysis of teacher behaviours. For each lesson, video- and audiotaping began when the first student entered the class and was ended when the last student left the class. Each lesson was supervised by two research assistants and the first author to ensure reliable data collection and to check whether the teacher correctly implemented the lesson plan. Participant reactivity was reduced through the introduction of the assistants and researcher by the teacher to the students, by videotaping one lesson prior to the start of the study, and by not communicating with the students during all interventions.

Primary data analysis

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Fourteen students (seven girls and seven boys) were excluded from the analysis because they did not participate in three or more swimming lessons. Data were collected on 74 students: 18 in the Traditional class (eight girls and ten boys), 20 in the Sport Education class (11 girls and nine boys), 17 in the Traditional-CK class (eight girls and nine boys), and 19 in the SE-CK class (seven girls and 12 boys). The average lesson time was 41 minutes (range 38-43 minutes).

Data were analyzed using version 19.0 of the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA). Kolmogorov-Smirnov testing did not show violations of the assumption of normality for independent variables ($p > .05$), and Levene's testing demonstrated equality of variances ($p > .05$). The amount of arm strokes performed over 50m as well as swimming performances were analysed using repeated measures analysis of variance (ANOVA). Significance level was set at $p = .05$. Effect sizes were reported by means of partial eta squared ($\eta p^{2)}$. The total volume of laps swum in each group was entered in the design as a covariate. No significant differences between groups were found for the amount of arm strokes at pretest, $F(3, 69) = .98$, $p = .40$, and for swimming performance, $F(3, 69) = .46$, $p = .71$. Teacher behaviour was reported in terms of total observations per group.

Results

Procedural fidelity

Procedural fidelity was measured in each condition. In the CK groups this was measured by coding each task in every lesson on four levels: (1) as taught, (2)

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partially correct, (3) different task but consistent with the workshop, or (4) different task and not consistent with the workshop. A fidelity score was computed by dividing the amount of tasks in each level with the total amount of tasks in that lesson, multiplied by 100. A total of 92% of tasks in all CK classes (range 89%-94%) were coded 'as taught', indicating high fidelity. Coding was performed by two trained research assistants. Mean interobserver agreement (IOA) was 93% obtained from 33% of all observations.

Procedural fidelity of both Sport Education groups was computed by dividing the observed Sport Education features in each class with the total amount of features taught during the Sport Education workshop (i.e., 10), multiplied by 100. For both Sport Education classes, all teacher behaviours were used indicating adherence to the Sport Education workshop. Coding was performed by two research assistants. Interobserver agreement was 99%.

Since the teacher received a Sport Education workshop prior to starting the study, contamination of his teaching in the Traditional class was controlled by asking the teacher to provide his written lesson plans for the 10-day swimming unit before starting to teach. These lesson plans were teacher-led and did not include Sport Education features. In the CK classes, no formal features of the Sport Education model were implemented. Two research assistants familiar with the Sport Education model (a) checked whether the plan was followed as written for the Traditional group, and (b) examined the videotaped lessons in both the Traditional and Traditional-CK group to assess whether the elements of Sport Education were used in these units. No changes were found.

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Teacher Behaviour

Verbal representations. Table 2 shows the total count of teacher's verbal representations in all groups. The amount of cues in the Traditional-CK and SE-CK groups increased about six-fold compared to the Traditional and Sport Education group. No analogies and metaphors were used in all groups. The amount of instructions and descriptions were relatively stable in all groups (range: 27-35). In the Traditional and Traditional-CK group, more specific congruent feedback was given compared to the Sport Education and the SE-CK group.

Visual representations. A larger amount of partially incorrect demonstrations was recorded in the Traditional (141) compared to the Sport Education (75), Traditional-CK (45), and the SE-CK (40) groups. The count of partially incorrect demonstrations was higher than the count of correct demonstrations in the Traditional (141 vs 87) and the Sport Education group (75 vs 38). In Sport Education classes, the count of task card instruction was higher compared to the non-Sport Education classes (41 and 28 vs 18 and 17). No incorrect demonstrations were recorded (see Table 2).

Task maturity and developmental appropriateness. The total count of immature but developmentally appropriate tasks was higher in the Traditional (29) and Sport Education group (18) compared to the Traditional-CK (3) and SE-CK group (2). A higher total count was found for mature and developmentally appropriate tasks in the Traditional-CK (25) and SE-CK (24)

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group compared to the Traditional (6) and the Sport Education group (7) (see Table 2).

INSERT TABLE 2

Arm strokes

Means and standard deviations can be found in Table 2. Repeated measures analysis did not show a significant time effect, $F(1, 69) = .34$, $p = .56$, $\eta p^2 = .01$. A significant group effect was found, $F(3, 69) = 3.96$, $p = .04$, $\eta p^2 = .13$. Post hoc testing demonstrated a significantly lower number of strokes in the Traditional-CK ($M = 43$) and the SE-CK ($M = 45$) group compared to the Traditional ($M = 53$), $p < .05$. A time x group interaction was found indicating a decrease of strokes in the CK groups, $F(3, 60) = 7.17$, $p < .01$, $\eta p^2 = .27$ (see Figure 1).

INSERT FIGURE 1

Swimming Performance

Means and standard deviations can be found in Table 3. Repeated measures showed no significant time effect, $F(1, 69) = 1.45$, $p = .23$, $\eta p^2 = .02$. No significant group effect was found, $F(1, 69) = 1.65$, $p = .19$, $\eta p^2 = .08$. A significant time x group interaction revealed a larger increase in swimming performance in the CK groups compared to the Traditional and Sport Education group, $F(3, 69) = 3.73$, $p = .02$, $\eta p^2 = .16$ (see Figure 2).

Amount of laps swum

One-way ANOVA showed a significant difference in the total amount of laps swum between groups, $F(3, 69) = 32.1$, $p < .001$, $\eta p^2 = .61$. Students in the

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Sport Education group swam significantly more laps during the 10-lesson unit (200) compared to the Traditional (164), the Traditional-CK (153) and the SE-CK group (160).

INSERT TABLE 3 and FIGURE 2

Discussion

In this study we sought to add to the research base by exploring relationships between CK, PCK and student learning. We used an experimental strategy to investigate (1) how a teacher's enacted PCK differed as a function of CK and Sport Education; and (2) the relative contribution of CK and Sport Education to student learning in terms of swimming performance. The results for student learning can be summarized as follows. In the Traditional group students neither improved their swimming performance (e.g., 50m sprint) nor did they decrease the amount of strokes throughout the 10-day unit. Students in this group swam an average of 164 laps. In the Sport Education group, students swam 22% (i.e., 200) more laps compared to the traditional groups and compared to the SE-CK group. However in this condition their performance did not improve nor did their amount of strokes decrease. In the Traditional-CK group, students swam the least amount of laps (153), yet they decreased the amount of strokes the most as indicated by a time by group effect showing larger improvement in the CK groups. A similar effect is reported for the 50m sprint time. In the SE-CK group students swam on average 160 laps and a time by group effect demonstrated larger swimming gains compared to the Traditional and Sport Education group. These results show the impact on

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student learning when CK was added to both traditional and Sport Education conditions.

Because observational and qualitative studies of PCK have consistently hypothesized the critical role that CK has on enacted PCK in this study we provided CK to enhance both the traditional and Sport Education conditions with the intent of demonstrating the differential effects CK would have on enacted PCK. We examined the enacted PCK of the teacher in each condition using (a) the maturity of the task that was selected for the students as a marker of the influence of SCK on PCK, (b) the quality of demonstrations as a marker of the teacher's CCK, and (c) congruence of feedback as a marker of teacher knowledge of SCK. Our results show that in terms of the teacher's task maturity and appropriateness in the traditional and Sport Education groups, most tasks were immature, but developmentally appropriate. In contrast in the CK groups, most tasks were both mature and appropriate. The importance of CK as a missing paradigm in teaching effectiveness research was emphasized by Shulman (1987 p. 8) nearly three decades ago who observed that how the subject matter is "organized, represented and adapted to the diverse interests and abilities of learners" is a defining feature of good PCK and thus of an effective teacher. Previous research has demonstrated a close relationship between subject-matter expertise and the way how content is presented and sequenced (Hastie and Vlaisavljevic 1999; Rovegno, Chen and Todorovich 2003). In the CK workshop, SCK in the form of specific tasks and sequences of tasks designed to teach specific performance outcomes of the front crawl

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were taught to teachers. The CK workshop in this study changed the quality of the tasks used by the teacher in the SE-CK and Traditional-CK condition.

In terms of how the task was demonstrated to the students, we found that in the Traditional and the Sport Education group, the number of partially correct demonstrations exceeded the number of correct demonstrations between 170 and 200% whereas the opposite was observed in both SE-CK and Traditional-CK condition groups. In the workshop the teacher was asked to demonstrate the task he was teaching (i.e., CCK). Rink (1994) has argued that demonstrations are crucial for student learning since they represent the most common way students come to understand the task. Similar to studies focusing on task demonstration (Graham 1988; Graham, Hussey, Taylor et al. 1993), improved CK led to improved demonstrations in lessons.

McCaughtry and Rovegno (2003) note that the ability to provide feedback is tied to CK. Feedback requires errors to be identified (i.e., SCK), meaningful feedback to be provided (i.e., PCK). Our findings for feedback were that in the Sport Education groups less specific congruent feedback was provided by the teacher compared to Traditional and CK groups. These results may be related to the nature of Sport Education. In the Sport Education groups, student coaches mostly provided this type of feedback whereas the teacher provided other types of feedback such as the use of task cards.

In summary, the primary finding of this study is that students in the Traditional and Sport Education group did not get the same quality of instruction as students in the Traditional-CK and SE-CK condition. The latter

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groups received content that was presented differently both as a presentation and in terms of the actual task. In short, students in the Traditional and Sport Education condition experienced the content differently than those in the Traditional-CK and SE-CK condition. These differences in instruction resulted in students in the Traditional-CK and SE-CK condition improving their swimming performances in terms of technical efficiency and in terms of 50m times. CK has been frequently hypothesized as influencing PCK (Ayvazo and Ward 2011; Graham 1988; Graham et al. 1993; McCaughtry and Rovegno 2003; Rovegno et al. 2003; Siedentop 2002; Ward 2009). This study is among the first to experimentally demonstrate this relationship. The changes to the teacher's enacted PCK were immediate and consistently maintained across the 10 days in both the Traditional-CK and SE-CK conditions.

In our introduction we situated this study in the context of arguing that teacher quality impacts student learning through the creation of quality learning environments. We argued that many pedagogical interventions are package interventions (e.g., Sport Education) consisting of instructional and in some cases managerial elements. In framing this argument we contended that CK is a critical element of these pedagogical interventions. This finding has important implications for the inclusion of CK and in particular, SCK in the preservice and the continuing professional development of teachers.

There are several limitations inherent in this study. First, in this exploratory study we used students as the unit of analysis where more correctly class should have been used. Though the descriptive data show substantive

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differences between Traditional and Sport Education group compared to the Traditional-CK and SE-CK condition contributing to the internal validity of our study, we are nonetheless unable to generalize beyond this context. Future studies should focus on not only demonstrating effect sizes but also the generality of findings. Second, this was a 10-day unit of swimming instruction. While this exceeds the typical length of a unit of instruction in Belgium (i.e., most units are 4 to 8 days in duration), it is not the preferred duration for Sport Education units. Siedentop et al. (2011) have argued that engagement in an extended season creates opportunities for understanding, shared learning and accomplishment that typically do not occur in instructional units of shorter durations. Although speculative, one could assume that a longer unit would increase the already existing differences between the CK and non-CK groups.

Third, in this study our focus was on psychomotor outcomes. Sport education focuses on several other outcomes that we did not measure. It would be erroneous to conclude that the Sport Education conditions did not impact variables such as motivation. The high number of laps swum in the Sport Education condition could be an indicator of student motivation. Future studies should consider the measurement of motivational variables and knowledge. Particularly in the context of Metzler's (2011) contention that different instructional models purposely produce different outcomes.

Fourth, we rely in this study on the assumption that the knowledge acquired in the workshops for Sport Education and for CK were responsible for the

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changes in student learning. While there are measures of procedural fidelity for each condition that examine the extent to which teaching behaviors and instructional contexts characterize each condition we did not directly measure teacher knowledge. At present there are no validated assessments of teacher CCK and SCK in physical education. There is a pressing need for the development of such knowledge tests. Finally, the organization of the Sport Education unit was limited in a number of ways in this study. Our focus on swimming as opposed to a racquet or invasion game allowed for a closely controlled context focusing on the front crawl, but the transfer to other activities such as invasion games is unknown. Future studies ought to replicate our protocols in other sports and activities.

Conclusion

The strengths of this study include the operationalization of CK as CCK and SCK. Being able to design the elements of the workshop to focus on the CCK and SCK represents an important contribution to the professional development literature. Although research is needed to examine the qualitative components of such workshops, the results of this study provide a validation of its design. A second strength of this study lies in the operationalization and measurement of PCK. This is among the first studies in physical education to provide a direct measure of PCK. In each of the three variables used, task maturity, demonstrations, and congruent feedback teachers enacted PCK was able to be differentiated among conditions. Though demonstrations and feedback have been used in many teacher effectiveness studies, the maturity of the task has

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only been discussed in observational or qualitative studies to date. As such this represents an important contribution to the literature. Finally our intent in this study was not to argue in favour of a pedagogical intervention over another, but rather to demonstrate the important role that CK plays in the psychomotor outcomes of pedagogical interventions. Although more research is needed to provide a comprehensive picture of the role of CK, PCK and student learning the present study adds to the research base by providing evidence for the changes in teacher and student learning that occur when a teacher's CK is strengthened.

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Table captions

Table 1. Sport Education implementation fidelity

Table 2. Total count of teacher behavior in the Traditional, Sport Education, Traditional-CK, and SE-CK classes

Table 3. Repeated measures analysis of pre –and posttests of arm strokes and swimming performances in the Traditional, Sport Education, Traditional-CK, and SE-CK group

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722 Table 1. Sport Education implementation fidelity

Preparation	Fidelity Indicator/Example	SE	SE-CK
Teacher trained in the Sport Education Model	The teacher attended a 3-hour Sport Education workshop in which the relevant Sport Education features were taught (Siedentop, et al., 2011).	√	NA
Teacher Planning	The teacher prepared the daily lesson plans taking into account the Sport Education features taught during the workshop. All lesson plans were reviewed by the primary investigator ensuring implementation of the Sport Education features.	√	√
The teacher trialed the Sport Education curriculum with a class not associated with the study.	Feedback from the lead investigator was provided and refinement by the teacher occurred during this unit.	-	-
Sport Education Features serving as Benchmarks			
Unit organized as a season that is longer than the typical 10-12 lesson unit.	It was not possible to convince the teacher and the school to extend the 10 day unit they typically use in this school and region (See	A	A

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	discussion).		
Students are organized into mixed ability teams for the duration of the unit.	- Students remained in the same mixed ability team determined by the teacher for the entire duration of the swimming unit. - Teams had assigned spaces in the swimming pool including a "team home lane".	D D	D D
Students learned multiple roles	- Students were assigned roles in addition to their 'swimmer' role including coach (instructing lesson content, provision of feedback), captain (communication with teacher, checking attendances, leading the team), and manager (responsible for equipment such as portfolios, swim caps). - The teacher modeled the roles during the first day of the unit. During the unit, the teacher followed up these roles and tried to keep in control of the managerial aspects of these roles. For example: the student-coach was responsible for instructing the team members the tasks given by the teacher on task cards. To facilitate the provision of these tasks in a qualitative way, the teacher controlled the managerial aspects: after handing over the task cards, the coaches were given a certain amount of time to read the tasks by themselves. Next, the teacher asked teams to get together and listen carefully to the coach for a defined amount of time (depending on the task).	D D	D D

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	Finally, teammates were allowed to ask their coach questions (again for a certain amount of time) and after a whistle blow by the teacher the teams got started.		
Activities were modified to encourage engagement of all the students.	- Students often worked in pairs on developmentally appropriate tasks. - The teacher used 'team averages' on the level of arm strokes and 50m swim time to ensure engagement of high as well as low-skilled students.	D	D
Team gradually introduced to techniques and tactics	- Teacher acted as a facilitator during interactions with teams. - The teacher provided task cards for coaches. - The tasks became more complex over the course of the unit (e.g., from tasks focusing on the reduction of drag to tasks focusing on coordination).	D D D	D D D
The season includes developmentally appropriate competitions	Students engaged in team challenges (e.g., Which team holds the lowest average amount of strokes needed for 50 meters? Which team has the highest average improvement for the 50m time?) and did scrimmages within their team (e.g., Which team member can float at least three meters after a turning point?).	D	D
Organizational format for competitions	- Teams engaged in scrimmages, regular season phase and an end-of-season event.	P	P
Records are kept during the season	Team performances (e.g., times, challenge results) and assessments	D	D

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	(e.g., students' 50m swim time and team average, students' amount of strokes for swimming 50m and team average, completed tasks) were recorded in the portfolios and posted on the scoreboard.		
Season champions are determined by a point system	Points were awarded for: - Highest performing team on the level of role responsibility fulfillment. - Highest performing team in terms of receiving daily bonus points for exceptionally good role fulfillment. - Highest reduction in team average for 50m swim time. - Highest reduction in team average for the amount of strokes for 50m. - Fastest team in 50m sprint.	D D P P P	D D P P P
The season is designed to be festive with a culminating experience	- Teams had a separate bulletin board where they posted their team results. - Teams were named after important swimming countries such as USA, Japan, and the Netherlands. - Team members wore a swim cap with their nation's flag on it. - There were individual team bulletin boards - Teams had individual portfolios with their nation's flag on it which contained	D D D D D	D D D D D

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	lesson tasks, attendance forms, task cards, and a description of role responsibilities). - The last day of the unit awards are given to teams (e.g., the team that improved most on the level of time, on the level of stroke reduction, on the level role performances).	P	P

Note: "A" indicates the absence in this study of a feature; "D" indicates that the feature was present during the Sport Education unit (i.e., >80% of the lessons); "P" indicates the feature was present as appropriate; and "NA" indicates 'not applicable'.

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726 Table 2. Total count of teacher behavior in the Traditional, Sport Education (SE), Traditional-CK, and SE-CK group

	Traditional	SE	Traditional-CK	SE-CK
Verbal Representations				
Instructions	38	38	34	34
Descriptions	35	27	29	33
Analogies/metaphors	0	0	0	0
Cues	5	5	37	30
Specific Congruent Feedback	162	67	116	65
Visual Representations				
Correct Demos	87	38	81	78
Partially Correct Demos	141	75	46	40
Incorrect Demos	0	0	0	0
Task Cards	18	41	17	28
Physical Aid	1	0	0	2
Task Maturity				
Mature and Appropriate (4)	6	7	25	24

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Mature and Developmentally inappropriate (3)	6	6	1	2	727
Immature Developmentally Appropriate (2)	29	18	3	2	728
Immature and Inappropriate (1)	0	0	0	0	

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Table 3. Repeated measures analysis of pre –and posttests of arm strokes and swimming performances in the Traditional, Sport Education (SE), Traditional-CK, and SE-CK group

	Traditional (n=19)	SE (n=18)	Traditional-CK (n= 19)	SE-CK (n=18)	Time	Group	Time x group
	M (SD)	M (SD)	M (SD)	M (SD)		P- values	
Arm strokes pretest	53 (11)	47 (10)	47 (10)	49 (9)			
Arm strokes posttest	53 (13)	45 (9)	37 (9)	41 (8)			
Mean Difference pre post	0 (15)	-2 (7)	-10 (7)	-8 (7)	.56	.04	<.001
Swimming performance pretest	134 (124)	134 (70)	159 (76)	159 (80)			
Swimming performance posttest	160 (125)	155 (74)	212 (72)	198 (82)			
Mean Difference pre post	+26 (37)	+21 (44)	+53 (34)	+39 (26)	.23	.19	.02

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Figure captions

Figure 1. Arm strokes at pretest and posttest in the Traditional, Sport Education, Traditional-CK, and SE-CK group.

Figure 2. Swimming scores at pretest and posttest in the Traditional, Sport Education, Traditional-CK, and SE-CK group.

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749

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Figure 1. Arm strokes at pretest and posttest in the Traditional, SE, Traditional-CK, and SE-CK group.

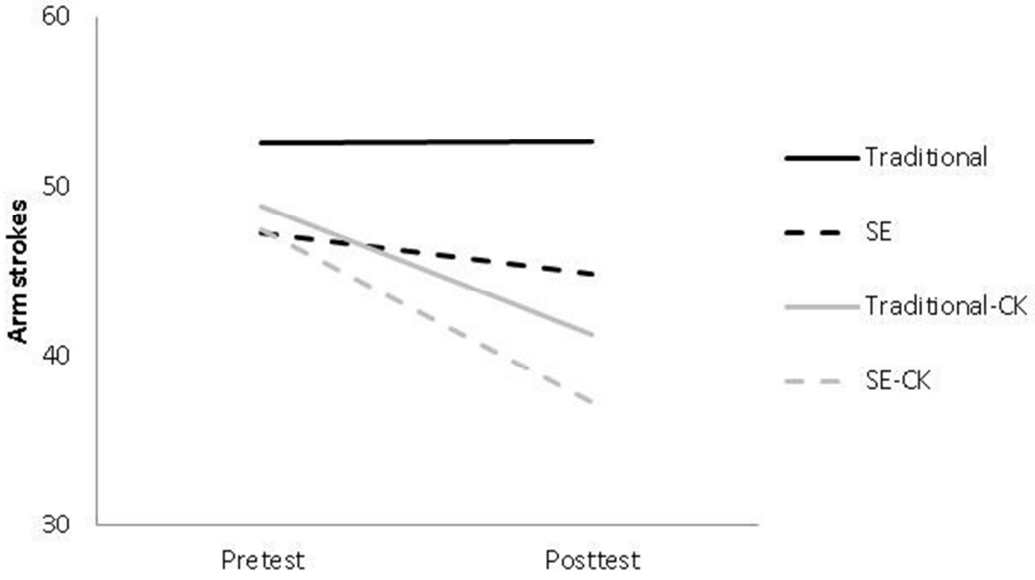

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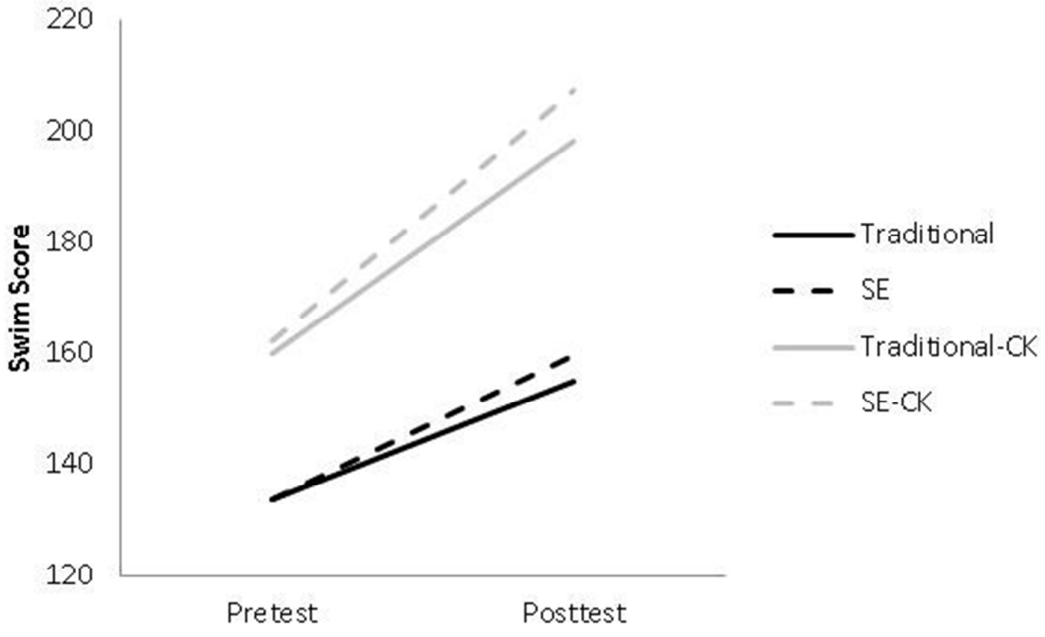
Figure 2. Swimming scores at pretest and posttest in the Traditional, SE, Traditional-CK, and SE-CK group.



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Sport Education Features serving as Benchmarks			
Unit organized as a season that is longer than the typical 10-12 lesson unit.	It was not possible to convince the teacher and the school to extend the 10 day unit they typically use in this school and region (See discussion).	A	A
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	and team average, completed tasks) were recorded in the portfolios and posted on the scoreboard.		
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Swimming performance pretest	134	(124)	134	(70)	159	(76)	159	(80)			
Swimming performance posttest	160	(125)	155	(74)	212	(72)	198	(82)			
Mean Difference pre post	**+26**	**(37)**	**+21**	**(44)**	**+53**	**(34)**	**+39**	**(26)**	**.23**	**.19**	**.02**

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This experimental study was conducted to investigate how a teacher's enacted Pedagogical Content Knowledge (PCK) differed as a function of Content Knowledge (CK) and Sport Education (SE); and to investigate the relative contribution of CK and Sport Education on student learning in terms of swimming performance. Four intact classes comprising 88 secondary school students (age: 16-17 years) were randomly assigned to a Traditional, a Sport Education, a Traditional-CK, and a SE-CK group. All classes were taught by the same teacher during a 10-day unit of instruction in the front crawl. Results showed that the teacher's PCK differed as a function of improved CK. Students achieved higher learning in the Traditional-CK and SE-CK groups, and the Sport Education model alone did not contribute to students' swimming performance. This study demonstrates the important role that CK plays in both PCK and student learning.

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